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Wister Reservoir
Leflore County, Oklahoma

National Eutrophication Survey, Las Vegas, Nev

Prepared for

Environmental Monitoring and Support Lab, Las Vegas, Nev

Mar 77

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REPORT

ON

WISTER RESERVOIR

LEFLORE COUNTY

OKLAHOMA

EPA REGION VI

WORKING PAPER No. 505

WITH THE COOPERATION OF THE

OKLAHOMA DEPARTMENT OF POLLUTION CONTROL

AND THE

OKLAHOMA NATIONAL GUARD

MARCH, 1977

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16. ABSTRACT

Annual total phosphorus and total nitrogen loadings to the lake were estimated and subdivided according to either point or non-point source origin. An assessment of the lake's trophic condition and limiting nutrient is also provided. All data collected by the U.S.E.P.A. National Eutrophication Survey during the one year study of the lake and its tributaries are included in the report.

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REPORT ON WISTER RESERVOIR

LEFLORE COUNTY, OKLAHOMA

EPA REGION VI

by

National Eutrophication Survey

Water and Land Monitoring Branch
Monitoring Applications Laboratory
Environmental Monitoring & Support Laboratory
Las Vegas, Nevada

and

Eutrophication Survey Branch
Corvallis Environmental Research Laboratory
Corvallis, Oregon

Working Paper No. 595

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U.S. ENVIRONMENTAL PROTECTION AGENCY

March 1977

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FOREWORD

The National Eutrophication Survey was initiated in 1972 in response to an Administration commitment to investigate the nationwide threat of accelerated eutrophication to freshwater lakes and reservoirs.

OBJECTIVES

The Survey was designed to develop, in conjunction with state environmental agencies, information on nutrient sources, concentrations, and impact on selected freshwater lakes as a basis for formulating comprehensive and coordinated national, regional, and state management practices relating to point source discharge reduction and nonpoint source pollution abatement in lake watersheds.

ANALYTIC APPROACH

The mathematical and statistical procedures selected for the Survey's eutrophication analysis are based on related concepts that:

a. A generalized representation or model relating sources, concentrations, and impacts can be constructed.

b. By applying measurements of relevant parameters associated with lake degradation, the generalized model can be transformed into an operational representation of a lake, its drainage basin, and related nutrients.

c. With such a transformation, an assessment of the potential for eutrophication control can be made.

LAKE ANALYSIS

In this report, the first stage of evaluation of lake and watershed data collected from the study lake and its drainage basin is documented. The report is formatted to provide state environmental agencies with specific information for basin planning [§303(e)], water quality criteria/standards review [§303(c)], clean lakes [§314(a,b)], and water quality monitoring [§106 and §305(b)] activities mandated by the Federal Water Pollution Control Act Amendments of 1972.

Beyond the single lake analysis, broader based correlations between nutrient concentrations (and loading) and trophic condition are being made to advance the rationale and data base for refinement of nutrient water quality criteria for the Nation's freshwater lakes. Likewise, multivariate evaluations for the relationships between land use, nutrient export, and trophic condition, by lake class or use, are being developed to assist in the formulation of planning guidelines and policies by the U.S. Environmental Protection Agency and to augment plans implementation by the states.

ACKNOWLEDGMENTS

The staff of the National Eutrophication Survey (Office of Research and Development, U.S. Environmental Protection Agency) expresses sincere appreciation to the Oklahoma Department of Pollution Control for professional involvement, to the Oklahoma National Guard for conducting the tributary sampling phase of the Survey, and to those Oklahoma wastewater treatment plant operators who provided effluent samples and flow data.

Dr. Denver Talley, Director, Oklahoma Department of Pollution Control; the staff of the Oklahoma Water Resources Board; and the staff of the Oklahoma State Department of Health reviewed the preliminary reports and provided critiques most useful in the preparation of this Working Paper Series.

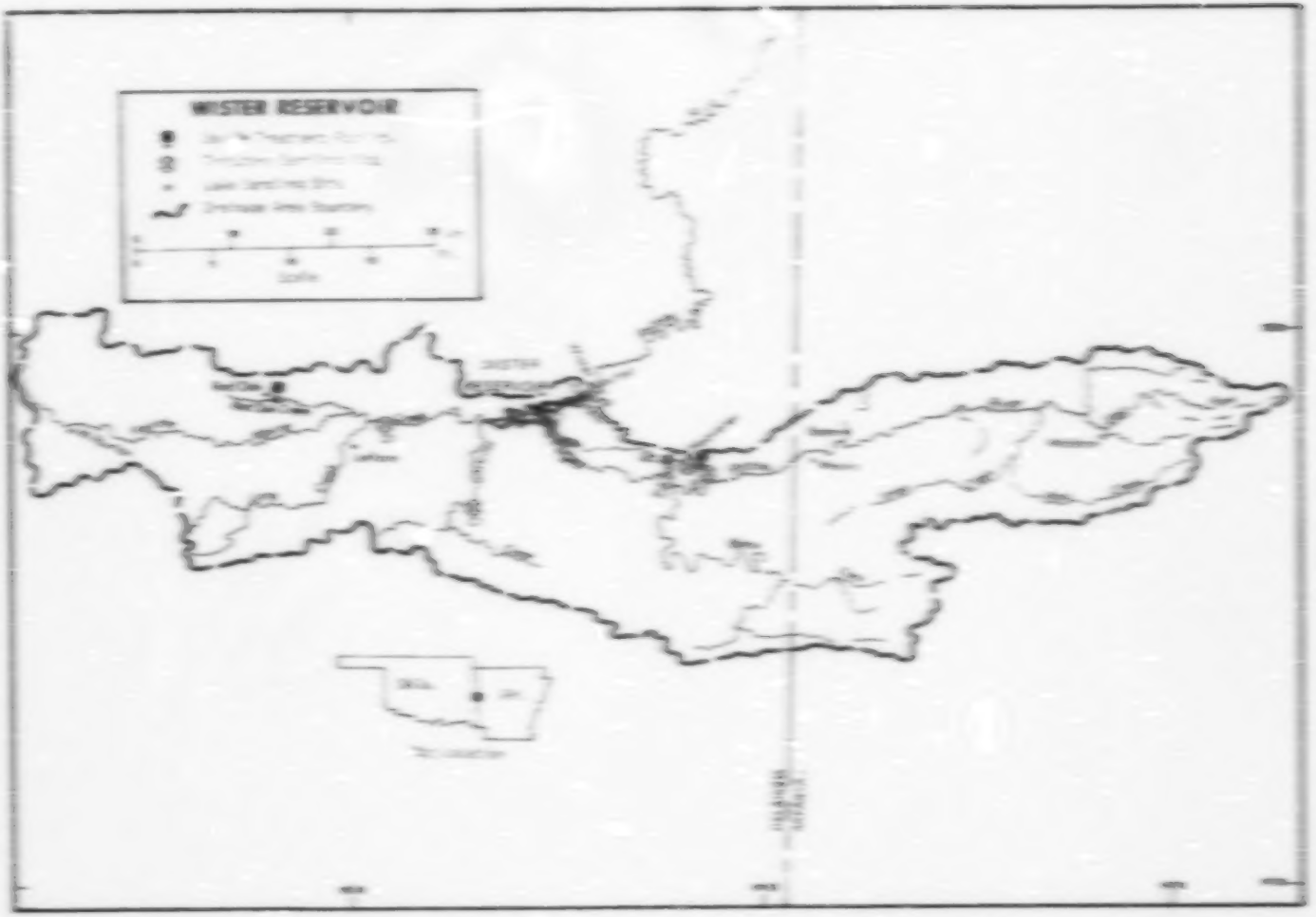
Major General John Coffey, Jr., the Adjutant General of Oklahoma, and Project Officers Colonel Curtis V. Milligan and Major James C. Heney, Jr., who directed the volunteer efforts of the Oklahoma National Guardsmen, are also gratefully acknowledged for their assistance to the Survey.

NATIONAL EUTROPHICATION SURVEY

STUDY LAKES

STATE OF OKLAHOMA

LAKE NAME	COUNTY
Altus Reservoir	Greer, Kiowa
Arbuckle Lake	Murray
Lake Elsworth	Caddo, Comanche
Lake Eufaula	Haskell, McIntosh, Okmulgee, Pittsburg
Fort Cobb Reservoir	Caddo
Fort Supply Reservoir	Woodward
Foss Dam Reservoir	Custer
Lake Frances	Adair
Grand Lake O' The Cherokees	Mayes, Delaware, Craig, Ottowa
Lake Hefner	Oklahoma
Keystone Reservoir	Tulsa, Creek, Osage, Pawnee
Oologah Lake	Nowata, Rogers
Tenkiller Ferry Reservoir	Cherokee, Sequoyah
Lake Thunderbird	Cleveland
Wister Reservoir	Leflore


WISTER RESERVOIR

REPORT ON WISTER RESERVOIR, OKLAHOMA

STORET NO. 4015

I. CONCLUSIONS

A. Trophic Condition:*

Survey data indicate that Wister Reservoir is eutrophic, i.e., nutrient rich and productive. Whether such nutrient enrichment is to be considered beneficial or deleterious is determined by its actual or potential impact upon designated beneficial water uses of each lake.

Nutrient levels in Wister Reservoir were quite high: of the 16 Oklahoma lakes (including Lake Texoma) sampled in 1974, only 4 had higher median total phosphorus levels, 7 had higher median inorganic nitrogen values, and 6 had higher median orthophosphorus levels than this reservoir. Potential for primary productivity, as measured by algal assay control yield, was high in spring and moderate during fall sampling. Chlorophyll *a* values ranged from 2.7 µg/l to 8.4 µg/l, with a mean of 4.8 µg/l.

Survey limnologists did not observe macrophytes or surface algal concentrations during their sampling visits. However, it was noted that the lake at times was very turbid, and the low Secchi disc transparencies (range of 0.3 to 0.9 meters) suggest

*See Appendix E.

that primary productivity in Wister Reservoir may have been light-limited, even though no clear-cut direct relationship was noted between light penetration and chlorophyll a levels.

B. Rate-Limiting Nutrient:

The algal assay results indicate that the primary limiting nutrient in Wister Reservoir was phosphorus at the times of sampling. The lake data indicate phosphorus limitation in June and October, respectively, and primary limitation by nitrogen in March and August.

C. Nutrient Controllability:

1. Point sources -

During the 1974 sampling year, point sources were estimated to have contributed 6.1% of the total phosphorus load to Wister Reservoir. The town of Heavener contributed 4.9% and Red Oak contributed 1.2%.

Loading calculations based upon available nutrient concentrations yield a net export of both phosphorus and nitrogen from the reservoir, indicating that sampling was not adequate to depict actual loading and/or export rates from Wister Reservoir. This export might be attributable to an underestimation of nutrient loading from the known point sources and septic tanks, or to sampling error. It is known that a waterfowl refuge exists on Wister Reservoir; additional study to determine the nutrient impact of this refuge on the reservoir is needed.

The total annual phosphorus loading to Wister Reservoir is 2.69 g $P/m^2/yr$, twice that proposed by Vollenweider (1975) as "eutrophic" for a lake with such volume and hydraulic retention time. However, Vollenweider's model may not be applicable to lakes with short retention times (16 days for Wister Reservoir) or in which epilimnetic light penetration is severely reduced by the presence of suspended sediments in the surface waters. In any case, it does not appear likely that point source phosphorus control would result in any appreciable improvement in the trophic condition of the lake.

2. Nonpoint sources -

Nonpoint sources, including precipitation, were calculated to have contributed 33.9% of the total phosphorus load to Wister Reservoir. The Poteau River contributed 45.2%, Fourche Maline Creek contributed 40.6%, and ungaged tributaries were estimated to contribute 5.0%.

II. LAKE AND DRAINAGE BASIN CHARACTERISTICS

Lake and drainage basin characteristics are itemized below. Lake surface area and mean depth were provided by the Oklahoma Department of Pollution Control; maximum depth was provided by the Oklahoma Water Resources Board. Tributary flow data were provided by the Oklahoma District Office of the U.S. Geological Survey (USGS). Outlet drainage area includes the lake surface area. Mean hydraulic retention time was obtained by dividing the lake volume by mean flow of the outlet. Precipitation values are estimated by means as outlined in National Eutrophication Survey (NES) Working Paper No. 175. A table of metric/English conversions is included as Appendix A.

A. Lake Morphometry:

1. Surface area: 16.19 km^2.
2. Mean depth: 2.3 meters.
3. Maximum depth: 13.4 meters.
4. Volume: 37,237 x 10^6 m3.
5. Mean hydraulic retention time: 16 days.

B. Tributary and Outlet:
(See Appendix B for flow data)

1. Tributaries -

Name	Drainage area(km^2)	Mean flow (m^3/sec)
A-2 Poteau River	1,320.9	14.91
B-1 Oil Branch	4.5	0.04
C-1 Holston Creek	149.7	1.82
D-1 Fourche Maline Creek	686.3	7.36
Minor tributaries and immediate drainage -	393.0	4.35
Totals	2,554.4	28.18
2. Outlet - A-1 Poteau River	2,570.7	27.35

C. Precipitation:

1. Year of sampling: 122.4 cm.
2. Mean annual: 115.4 cm.

III. LAKE WATER QUALITY SUMMARY

Mister Reservoir was sampled four times during the open-water season of 1974 by means of a pontoon-equipped Huey helicopter. Each time, samples for physical and chemical parameters were collected from two stations on the lake and from a number of depths at each station (see map, page v). During each visit, depth-integrated samples were collected from each station for chlorophyll a analysis and phytoplankton identification and enumeration. During the first and last visits, 18.9-liter depth-integrated samples were composited for algal assays. Maximum depths sampled were 12.2 meters at Station 01 and 10.7 meters at Station 02. For a more detailed explanation of NES methods, see NES Working Paper No. 175.

The results obtained are presented in full in Appendix C and are summarized in III-A for waters at the surface and at the maximum depth for each site. Results of the phytoplankton counts and chlorophyll a determinations are included in III-B. Results of the limiting nutrient study are presented in III-C.

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B. Biological Characteristics:

1. Phytoplankton

Sampling Date	Dominant Genera	Algal Units per ml
03/28/74	1. Melosira	488
	2. Ankistrodesmus	325
	3. Chromonas	293
	4. Cryptomonas	163
	5. Flagellates	65
	Other genera	358
	Total	1,692
06/07/74	1. Melosira	3,422
	2. Flagellates	254
	3. Nitzschia	95
	4. Coelastrum	32
	Other genera	----
	Total	3,803
08/26/74	1. Melosira	344
	2. Anabaena	31
	3. Ankistrodesmus	31
	4. Closterium	31
	5. Cryptomonas	31
	Other genera	187
	Total	655
10/21/74	1. Melosira	2,479
	2. Dactylococcopsis	303
	3. Nitzschia	220
	4. Kirchneriella	138
	5. Cryptomonas	83
	Other genera	494
	Total	3,717

F. Chlorophyll a -

Sampling Date	Station Number	Chlorophyll a (ug/l)
03/28/74	01	5.3
	02	7.6
06/07/74	01	6.5
	02	7.7
08/26/74	01	4.3
	02	3.9
10/21/74	01	4.8
	02	8.4

C. Limiting Nutrient Study -

1. Autoclaved, filtered, and nutrient spiked -

Spike(mg/l)	Ortho P Conc.(mg/l)	Inorganic N Conc.(mg/l)	Maximum Yield (mg/l-dry wt.)
a. 03/28/74			
Control	0.020	0.119	2.5
0.05 P	0.070	0.119	4.6
0.05 P + 1.0 N	0.070	1.119	23.0
1.00 N	0.020	1.119	2.3
b. 10/21/74			
Control	0.010	0.158	0.9
0.05 P	0.060	0.158	5.6
0.05 P + 1.0 N	0.060	1.158	17.3
1.00 N	0.010	1.158	0.6

2. Discussion -

The control yield of the assay alga, Selenastrum capricornutum, indicates that the potential primary productivity in Wister Reservoir was high at the time of spring sampling (03/28/74) and moderate during fall (10/21/74). The control yields would likely have been higher still had there been no substantial nutrient loss between sampling and assay. In both assays, there was a significant increase in yield over that of the control when orthophosphorus was added, indicating phosphorus limitaton. The addition of nitrogen alone did not result in an increase in yield over that of the control.

Mean inorganic nitrogen to orthophosphorus (N/P) ratios in the lake data were 24/1 and 20/1 in June and October, respectively, supporting primary limitation by phosphorus in

Wister Reservoir. Mean N/P ratios were 6/1 and 7/1, respectively, in March and August, however, suggesting nitrogen was the primary limiting nutrient upon those sampling occasions.

E. Limiting Nutrient Study -

1. Autoclaved, filtered, and nutrient spiked -

Spike(mg/l)	Ortho P Conc.(mg/l)	Inorganic N Conc.(mg/l)	Maximum Yield (mg/l-dry wt.)
a. 03/20/74			
Control	0.020	0.119	2.5
0.05 P	0.070	0.119	4.6
0.05 P + 1.0 N	0.070	1.119	23.0
1.00 N	0.020	1.119	2.3
b. 10/21/74			
Control	0.010	0.158	0.9
0.05 P	0.060	0.158	5.6
0.05 P + 1.0 N	0.060	1.158	17.3
1.00 N	0.010	1.158	0.6

2. Discussion -

The control yield of the assay alga, Selenastrum capricornutum, indicates that the potential primary productivity in Wister Reservoir was high at the time of spring sampling (03/20/74) and moderate during fall (10/21/74). The control yields would likely have been higher still had there been no substantial nutrient loss between sampling and assay. In both assays, there was a significant increase in yield over that of the control when orthophosphorus was added, indicating phosphorus limitaton. The addition of nitrogen alone did not result in an increase in yield over that of the control.

Mean inorganic nitrogen to orthophosphorus (N/P) ratios in the lake data were 24/1 and 20/1 in June and October, respectively, supporting primary limitation by phosphorus in

Wister Reservoir. Mean N/P ratios were 8/1 and 7/1, respectively, in March and August, however, suggesting nitrogen was the primary limiting nutrient upon these sampling occasions.

IV. NUTRIENT LOADINGS
(See Appendix D for data)

For the determination of nutrient loadings, the Oklahoma National Guard collected monthly near-surface grab samples from each of the tributary sites indicated on the map (page v), except for the high runoff month of May when two samples were collected. Sampling was begun in November 1974, and was completed October 1975.

Through an interagency agreement, stream flow estimates for the year of sampling and a "normalized" or average year were provided by the Oklahoma District Office of the USGS for the tributary sites nearest the lake.

In this report, nutrient loads for sampled tributaries were determined by using a modification of a USGS computer program for calculating stream loadings. Nutrient loads indicated for tributaries are those measured minus known point source loads, if any.

Nutrient loadings for unsampled "minor tributaries and immediate drainage" ("ZZ" of USGS) were estimated by using the mean annual nutrient loads, in kg/km^2/yr, in Oil Branch and Holston Creek at Stations B-1 and C-1, and multiplying the means by the ZZ area in km^2.

Nutrient loads for the Heavener and Red Oak wastewater treatment plants were estimated at 1.134 kg P and 3.401 kg N/capita/yr.

A. Waste Sources:

1. Known municipal -

Name*	Pop.* Served	Treatment*	Mean Flow ($m^3/d \times 10^3$)	Receiving Water
Heavener	2,000	Trickling filter	0.757**	Dll Branch/ Poteau River
Red Oak	500	Stabilization pond	0.189**	Red Oak Creek/ Fourche Maline Creek

2. Known industrial - None

*U.S.EPA, 1971.
**Estimated at 0.3785 m^3/capita/day.

B. Annual Total Phosphorus Loading - Average Year:

1. Inputs -

Source		kg P/yr	% of total
a.	Tributaries (nonpoint load) -		
	A-2 Poteau River	21,140	45.2
	B-1 Oil Branch	25	0.1
	C-1 Holston Creek	1,110	2.4
	D-1 Fourche Maline Creek	18,965	40.6
b.	Minor tributaries and immediate drainage (nonpoint load) -	2,360	5.0
c.	Known municipal STP's -		
	Heavener	2,270	4.9
	Red Oak	565	1.2
d.	Septic tanks* -	5	<0.1
e.	Known industrial - None		
f.	Direct precipitation** -	285	0.6
	Totals	46,725	100.0
2.	Output - A-1 Poteau River	58,145	
3.	Net annual P export*** -	11,420	

*Estimate based on 10 lakeshore residences and 1 park.
**Estimated (see NES Working Paper No. 175).
***Export probably due to unknown sources and/or sampling error.

C. Annual Total Nitrogen Loading - Average Year:

1. Inputs -

Source	kg N/yr	% of total
a. Tributaries (nonpoint load) -		
A-2 Poteau River	360,475	54.3
B-1 Oil Branch	815	0.1
C-1 Holston Creek	21,695	3.3
D-1 Fourche Maline Creek	191,125	28.8
b. Minor tributaries and immediate drainage (nonpoint load) -	64,060	9.6
c. Known municipal STP's -		
Heavener	6,800	1.0
Red Oak	1,700	0.3
d. Septic tanks* -	140	<0.1
e. Known industrial - None		
f. Direct precipitation** -	17,480	2.6
Totals	664,290	100.0
2. Output - A-1 Poteau River	791,155	
3. Net annual N export*** -	126,865	

*Estimate based on 10 lakeshore residences and 1 park.
**Estimated (see NES Working Paper No. 175).
***Export probably due to unknown sources and/or sampling error.

D. Mean Annual Nonpoint Nutrient Export by Subdrainage Area:

Tributary	kg P/km²/yr	kg N/km²/yr
Poteau River	16	273
Oil Branch	6	181
Holston Creek	7	145
Fourche Maline Creek	28	278

E. Yearly Loadings:

In the following table, the existing phosphorus annual loading is compared to the relationship proposed by Vollenweider (1975). Essentially, his "eutrophic" loading is that at which the receiving waters would become eutrophic or remain eutrophic; his "oligotrophic" loading is that which would result in the receiving water remaining oligotrophic or becoming oligotrophic if morphometry permitted. A "mesotrophic" loading would be considered one between "eutrophic" and "oligotrophic".

Note that Vollenweider's model may not be applicable to water bodies with very short retention times or in which light penetration is severely restricted from high concentrations of suspended solids in the surface waters.

	Total Yearly Phosphorus Loading ($g/m^2/yr$)
Estimated loading for Wister Reservoir	2.89
Vollenweider's "eutrophic" loading	1.46
Vollenweider's "oligotrophic" loading	0.73

IV. LITERATURE REVIEWED

U.S. Environmental Protection Agency. 1971. "Inventory of Wastewater Treatment Facilities". EPA Publication No. OWP-1, Vol. 6. Office of Media Programs, Office of Water Programs, Washington, D.C.

U.S. Environmental Protection Agency. 1975. National Eutrophication Survey Methods 1973-1976. Working Paper No. 175. National Environmental Research Center, Las Vegas, Nevada, and Pacific Northwest Environmental Research Laboratory, Corvallis, Oregon.

Vollenweider, R. A. 1975. Input-Output Models With Special Reference to the Phosphorus Loading Concept in Limnology. Schweiz. Z. Hydrol. 37:53-84.

VI. APPENDICES

APPENDIX A

CONVERSION FACTORS

CONVERSION FACTORS

Hectares x 2.471 = acres

Kilometers x 0.6214 = miles

Meters x 3.281 = feet

Cubic meters x 8.107×10^{-4} = acre/feet

Square kilometers x 0.3861 = square miles

Cubic meters/sec x 35.315 = cubic feet/sec

Centimeters x 0.3937 = inches

Kilograms x 2.205 = pounds

Kilograms/square kilometer x 5.711 = lbs/square mile

APPENDIX B
TRIBUTARY FLOW DATA

[illegible] 8/12/77

LAKE CODE [illegible] LAKENET [illegible]

TOTAL [illegible] AREA OF LAKE(S) [illegible] 2571.7

SUB-CATCHMENT	SUB-CATCHMENT AREA(S) [illegible]	JAN	FEB	MAR	APR	MAY	MONTHLIZED FLOWS(CMS) JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANN
[illegible]	2571.7	35.41	37.96	51.54	52.67	62.05	14.29	4.88	4.21	5.48	7.36	18.42	22.37	27.25
[illegible]	1329.6	28.34	28.19	27.39	29.53	38.67	7.48	4.53	2.27	3.45	4.11	8.48	17.26	14.48
[illegible]	4.3	0.023	0.032	0.046	1.04	0.025	0.031	0.009	0.011	0.034	0.029	0.068	0.028	0.037
[illegible]	344.7	1.13	1.27	2.46	2.41	3.45	1.22	1.13	0.48	1.62	1.07	0.65	0.49	1.52
[illegible]	494.3	3.18	11.61	12.19	17.27	18.49	5.39	5.18	1.19	2.27	2.41	3.88	5.38	7.38
[illegible]	494.2	3.11	8.51	7.79	4.63	18.14	3.11	3.11	0.45	1.78	1.78	2.17	3.11	4.35

SUMMARY

TOTAL DRAINAGE AREA OF LAKE = 2571.7
SUM OF SUB-CATCHMENT AREAS = 2571.7

TOTAL FLOW IN = 339.37
TOTAL FLOW OUT = 339.74

[illegible] MONTHLY FLOWS AND ANNUAL FLOWS(CMS)

SUB-CATCHMENT	MONTH	YEAR	[illegible] FLOW	DAY	FLOW	DAY	FLOW	DAY	FLOW
[illegible]	11	74	91.197	2	1.499				
	12	74	92.313	17	66.915				
	1	75	27.653	15	34.263				
	2	75	84.396	13	105.596				
	3	75	62.442	29	6.435				
	4	75	73.629	22	3.759				
	5	75	61.354	12	112.444	22	38.299		
	6	75	63.486	12	66.369				
	7	75	31.408	6	38.315				
	8	75	1.594	15	6.596				
	9	75	3.453						
	10	75	6.369	7	6.39				
[illegible]	11	74	95.305	2	22.425				
	12	74	45.291	17	17.299				
	1	75	15.486	15	11.248				
	2	75	45.877	13	13.592				
	3	75	69.315	26	4.224				
	4	75	42.475	22	3.8				
	5	75	33.131	12	17.448	22	9.342		
	6	75	34.547	12	21.41				
	7	75	1.557	6	1.429				
	8	75	6.366	15	6.113				
	9	75	8.528						
	10	75	9.369	7	9.122				

APPENDIX C

PHYSICAL AND CHEMICAL DATA

[illegible] RESERVOIR DATA [illegible]

[illegible]
34 50 15.0 094 42 11.0 3
[illegible] RESERVOIR
[illegible] [illegible]

[illegible]

[illegible]

[illegible] [illegible]
[illegible] FEET [illegible] CLASS [illegible]

DATE	TIME	DEPTH	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
FROM	OF		TEMP		TRANSP	CNDUCTVY	PH	T ALK	DISS	TOT /LBL	%SATRTN	PHOS-TOT
TO	DAY	FEET	CENT	MG/L	SECCHI	FIELD	SU	MG/L	TOTAL	%	SATURTN	MG/L P
[illegible]	16	15 [illegible]	14.5		15	41	7.81	104	0.368	0.580	0.127	0.026
	16	15 [illegible]	14.5			42	8.33	104	0.368	0.580	0.128	0.025
	16	15 [illegible]	12.4			43	8.16	104	0.388	0.480	0.138	0.030
	16	15 [illegible]	11.1			38	7.49	106	0.128	0.480	0.148	0.021
[illegible]	16	38 [illegible]	24.2		19	62	8.80	28	0.178	0.780	0.159	0.012
	16	38 [illegible]	24.1			63	8.78	28	0.198	0.580	0.166	0.012
	16	38 [illegible]	23.7			62	8.67	29	0.206	0.580	0.168	0.010
	16	38 [illegible]	23.6			62	8.78	21	0.166	0.480	0.159	0.011
[illegible]	13	38 [illegible]	28.2		36	69	8.44	38	0.898	0.680	0.823	0.079
	13	38 [illegible]	27.2			68	8.58	31	0.898	0.481	0.828	0.077
	13	38 [illegible]	26.0			68	8.47	41	0.528	0.980	0.838	0.078
	13	38 [illegible]	22.4			136	8.53	47	1.888	1.581	0.638	0.021
[illegible]	16	25 [illegible]	17.7		32	41	8.38	38	0.348	0.780	0.158	0.018
	16	25 [illegible]	17.7			41	8.17	36	0.898	0.481	0.148	0.017
	16	25 [illegible]	17.6			43	8.25	33	0.186	0.481	0.138	0.017
	16	25 [illegible]	17.5			41	8.17	33	0.138	0.580	0.138	0.015

* VALUE KNOWN TO BE
LESS THAN INDICATED

[illegible]

[illegible]

[illegible]

DATE	TIME	DEPTH	[illegible]	[illegible]	[illegible]
FROM	OF				
TO	DAY	FEET	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	5.3	
	[illegible]	[illegible]	[illegible]		
	[illegible]	[illegible]	[illegible]		
	[illegible]	[illegible]	[illegible]		
[illegible]	[illegible]	[illegible]	[illegible]	6.5	
	[illegible]	[illegible]	[illegible]		
	[illegible]	[illegible]	[illegible]		
	[illegible]	[illegible]	[illegible]		
[illegible]	[illegible]	[illegible]	[illegible]	4.3	
	[illegible]	[illegible]	[illegible]		
	[illegible]	[illegible]	[illegible]		
	[illegible]	[illegible]	[illegible]		
[illegible]	[illegible]	[illegible]	[illegible]	4.0	
	[illegible]	[illegible]			1.0
	[illegible]	[illegible]	[illegible]		
	[illegible]	[illegible]	[illegible]		
	[illegible]	[illegible]	[illegible]		

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DATE	TIME	DEPTH	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

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DATE FROM TO	TIME OF DAY	DEPTH FEET	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

APPENDIX D

TRIBUTARY AND WASTEWATER TREATMENT PLANT DATA

[illegible]

[illegible]

DATE	TIME	DEPTH	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	FEET	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	21	75	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	14	40	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	11	19	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	10	45	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	10	34	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	10	24	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	11	01	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	13	19	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	12	59	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	13	07	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	10	45	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	13	40	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

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[illegible]			[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]			[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]			[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]			[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]			[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]			[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]			[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]			[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]			[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]			[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]			[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

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DATE	TIME	DEPTH	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	FEET	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	24	18	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	13	19	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	12	21	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	11	05	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	11	19	[illegible]	[illegible]	[illegible]	[illegible]	
[illegible]	11	34	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	12	05	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	12	53	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	24	47	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	24	36	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	13	35	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	18	16	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

APPENDIX E

PARAMETRIC RANKINGS OF LAKES SAMPLED BY NES IN 1974

STATE OF OKLAHOMA

LAKE DATA TO BE USED IN RANKING

LAKE CODE	LAKE NAME	MEDIAN TOTAL P	MEDIAN CHLOR A	MEAN SECCHI	MEAN CHLOR A	MEAN TP	MEDIAN TOTAL NITROGEN
4702	ALVIS WATERSHED	0.041	0.044	405.625	14.751	0.401	0.819
4672	BIRCH LAKE	0.120	0.170	443.604	7.827	17.400	0.849
4603	LAKE ELLSWORTH	0.037	0.070	454.440	6.438	9.400	0.886
4804	LAKE EMMA	0.041	0.405	447.513	4.363	14.200	0.826
4605	FOWL DUCK RESERVOIR	0.039	0.110	454.867	14.967	0.401	0.812
4606	FOWL SUPPLY RESERVOIR	0.170	0.135	485.241	5.733	7.898	1.834
4607	FOX JOHNSON RESERVOIR	0.047	0.094	463.857	4.862	0.400	1.834
4610	LAKE MANDEL	0.142	1.761	454.333	7.473	0.200	0.871
4611	BIRD LAKE OF THE CHEROK	0.197	0.740	499.857	0.768	14.401	0.839
4701	LAKE HEPNER	0.157	0.276	461.800	5.467	0.898	0.836
4711	KEYSTONE RESERVOIR	0.136	0.490	494.353	21.427	14.402	0.846
4712	WILSON LAKE	0.159	0.366	483.896	5.197	14.401	0.871
4713	TEXHILL FOWL RESERVOI	0.134	0.356	475.500	0.846	15.801	0.814
4714	LAKE THUNDERHILL	0.147	0.154	485.896	4.422	12.401	0.804
4715	WEST RESERVOIR	0.190	0.234	479.500	4.812	15.889	0.814
4834	THOMAS LAKE	0.045	0.266	466.675	12.326	14.867	0.814

PERCENT OF LAKES WITH SIGNIFICANT VALUES (NUMBER OF LAKES WITH SIGNIFICANT VALUES)

LAKE CODE	LAKE NAME	RECREATIONAL VALUES					
		OVERALL #	SWIMMING	SUNBATHING	BOATING	FISHING	SCENIC BEAUTY
4001	ALTUS RESERVOIR	45 (45)	100 (25)	47 (73)	13 (23)	65 (123)	73 (111)
4002	BRECKLE LAKE	100 (1)	40 (13)	43 (14)	53 (60)	33 (43)	43 (14)
4003	LAKE ELLSWORTH	61 (12)	44 (13)	40 (12)	33 (51)	60 (45)	67 (15)
4004	LAKE EUFAULA	28 (32)	33 (51)	27 (41)	100 (25)	47 (73)	33 (43)
4005	FORT COBB RESERVOIR	73 (111)	73 (111)	67 (131)	7 (13)	65 (111)	67 (171)
4006	FORT SUPPLY RESERVOIR	33 (51)	67 (14)	0 (0)	27 (41)	100 (25)	65 (43)
4007	PINE CAY RESERVOIR	61 (141)	60 (121)	64 (14)	67 (131)	60 (111)	100 (25)
4008	LAKE FORBES	0 (0)	0 (0)	7 (13)	47 (73)	93 (241)	7 (13)
4009	GRAND LAKE OF THE CHEROKEES	13 (23)	7 (13)	40 (41)	93 (93)	20 (33)	13 (31)
4010	LAKE HEFNER	47 (71)	40 (61)	67 (191)	73 (111)	67 (191)	20 (31)
4011	HENRYETTA RESERVOIR	7 (13)	13 (21)	13 (21)	0 (0)	13 (21)	0 (0)
4012	OLLIVER LAKE	40 (41)	29 (31)	25 (31)	60 (125)	33 (41)	27 (41)
4013	TEXHOMA-GOOD NEIGHBOR	47 (111)	27 (41)	100 (25)	67 (191)	3 (13)	50 (71)
4014	LAKE THUNDERBIRD	67 (131)	86 (91)	53 (81)	40 (61)	53 (91)	65 (171)
4015	WISTER RESERVOIR	27 (41)	47 (71)	33 (51)	93 (141)	3 (11)	45 (41)
4016	TEXAS LAKE	51 (81)	53 (81)	73 (111)	20 (31)	33 (41)	50 (71)